

## SPECIFICATION

### Pressure Welding Machine and Pressure Welding Method

The present invention pertains to a pressure welding machine and a pressure welding method with the features in the preamble of the principal claim.

Such a pressure welding machine is known in the form of a double-head friction welding machine from EP 0 246 239 B1. It comprises a frame with a machine bed, at which two friction welding heads are mounted in such a way that they are movable in opposite directions along a common feed axis. They are moved by two adjusting units with feed drives along the feed axis. The adjusting units are mounted adjustably at the machine frame and are fixed individually in the desired position at the machine bed by hydraulically actuated friction brakes. A central workpiece is connected to additional workpieces on both sides by friction welding with the double-head friction welding machine. The spindle rotations of the two friction welding heads are synchronized by a common countershaft provided with a motor and a brake. Different workpiece lengths result in different path lengths for the friction feed and the upsetting feed, which are generated by different lengths of extension of the feed drives. To absorb the upsetting forces during friction welding, which amount to several tons, the pressure welding machine has a massive frame and machine bed. This means a great design effort, and undesired deformations nevertheless cannot be absorbed. On the other

hand, the accessibility of the workplace is limited by the large frame construction.

EP 0 059 544 A1 shows another friction welding machine with spindles that are likewise synchronized by means of a countershaft. The adjusting units are fixed here rigidly and unmovingly to the machine bed.

5 The object of the present invention is to show a better pressure welding machine along with a pressure welding method.

This object is accomplished by the present invention with the features in the principal method claim and in the principal device claim.

10 The pressure welding machine being claimed has the advantage of requiring a substantially reduced design effort, and a larger working range and better accessibility of the workplace are also achieved at the same time. The forces occurring during upsetting are absorbed in a closed system of forces via the adjusting element, which relieves the load on the frame construction. At the same time, adjustment of the adjusting units in both directions with the feed drives along a preferably common and continuous guide plane can be achieved by means of the adjusting element. Moreover, this 15 adjustment may be symmetrical. Special advantages are offered here by the adjusting element being designed as a continuous spindle with two threads directed in opposite directions, which is connected to the adjusting units via corresponding nut mounts. A self-locking motion thread, which can absorb and support the strong upsetting forces, is favorable here.

A preferably likewise displaceable central clamping device, which is equipped with two workpiece holders, which are connected to the respective adjusting units associated with them via carriage adjusters, are present for the central workpiece. As a result, the central clamping device and the adjusting units can be positioned simultaneously and synchronously. Spring-loaded connection 5 between the carriage adjusters and the workpiece holders make [sic - Tr.Ed.] possible an evading motion of the workpiece holders to absorb the upsetting deformation of the central workpiece during the upsetting stroke.

The pressure welding machine being claimed has, moreover, a measuring means, which makes it possible to measure the true feeds and the pure shortenings of the workpiece during pressure 10 welding without the elastic deformations of the central workpiece that occur during upsetting. It is possible as a result to also extrapolate the process parameters determined during a pressure welding process for certain workpieces and workpiece lengths to other workpieces of the same kind but with different lengths. This was hitherto impossible because the elastic deformation of the central workpiece, which likewise changed during a change of the workpiece lengths and thus affected the 15 process parameters, was always contained in the path measured values. It is favorable for the measuring means being claimed to arrange a scale and a corresponding measuring head at the workpiece holder and at the associated welding head in such a way that they are movable in relation to one another, so that what is measured is precisely their motion. The elastic deformation of the central workpiece is eliminated via the elastically non-rigid mobility of the workpiece clamping 20 device.

The pressure welding machine being claimed can operate with any desired pressure welding

method. This may be, e.g., friction welding or welding with an arc moved magnetically or in another manner. The workpieces welded together may be rotationally symmetrical, but this is not a compulsory prerequisite.

Other advantageous embodiments of the present invention are described in the subclaims.

5 The present invention is schematically shown in the drawings as an example. Specifically,

Figure 1 shows a side view of a pressure welding machine in the opened inoperative position,

Figure 2 shows the pressure welding machine according to Figure 1 in the working position,  
and

10 Figure 3 shows an enlarged view of the middle area of the pressure welding machine  
according to Figure 1.

Figures 1 through 3 show schematic side views and different operating positions of a pressure welding machine (1). The pressure welding machine (1) is used to weld two, three or more workpieces (2, 3, 4), wherein one or more outer workpieces (3, 4) are welded to a central workpiece (2) at both ends. The pressure welding technique may be of any desired type. For example, it may be friction welding with direct motor drive or flywheel drive or welding with an arc moved magnetically or in another way, etc. The workpieces (2, 3, 4) are arranged along a preferably common feed axis or upsetting axis (41) and are moved toward one another and connected to one

another at the end of the pressure welding operation by an upsetting stroke.

The pressure welding machine (1) is designed as a so-called double-head machine. It comprises a frame (10) with a central clamping device (5) for the central workpiece (2), two mobile welding heads (13, 14) adjoining [same] on both sides and two adjusting units (17, 18) that in turn adjoin the latter on both sides with feed drives (23) for the welding heads (13, 14). The pressure welding machine (1) has, furthermore, a computerized, programmable machine and process control (not shown). The central clamping device (5), the welding heads (13, 14) and the adjusting units (17, 18) are all mounted at the frame (10) movably along the preferably common feed axis or upsetting axis (41) by means of travel carriages (8, 9, 15, 16, 19, 20) and are mounted and guided axially movably at a preferably likewise common carriage guide (12). The mounting and guiding may be brought about, e.g., by means of nontilting roller bearings or the like. The two outer adjusting units (17, 18) are connected to one another and supported by means of a common adjusting element (26) with an adjusting drive (25).

The adjusting element (26) is preferably designed as a continuous spindle (27) with two threads (28, 29), which are arranged at least at the end and are directed in opposite directions. These threads (28, 29) are designed each as motion threads, especially as left-handed and right-handed screw threads. They may be, e.g., trapezoid threads. The threads (28, 29) mesh with nuts (21, 22), which are connected to the adjusting units (17, 18) via extension arms. The spindle (27) is arranged under the welding heads (13, 14) and the adjusting units (17, 18) and is mounted rotatably in a machine bed (11). The spindle is located between the laterally spaced rails of the carriage guide (12) and may be arranged at the same level as these rails or just below them. The threads (28, 29) and/or the

spindle (27) may be fixed in any desired and suitable manner in the inoperative position when needed, e.g., by means of brakes, a thread self-locking mechanism or the like.

The upsetting forces that occur during pressure welding and are exerted by the feed drives (23) are transmitted by the nuts (21, 22) to the adjusting element (26) and to the spindle (27) and supported.

5 As a result, a closed frictional connection is obtained, which relieves the load on the frame (10).

Only overturning moments that may develop need to be absorbed via the carriage guide (12). The travel carriages (19, 20) of the adjusting units (17, 18) can, moreover, be additionally fixed in the operating positions at the carriage guide (12) and at the frame (10) by clamping means or the like.

10 As an alternative, the adjusting element (26) may have another suitable design. This also applies to the adjusting drive (25) of the adjusting element. It is designed as a spindle drive in the exemplary embodiment being shown and comprises a motor (30), which can be accurately controlled for precise positioning, preferably an electric motor. A reducing gear may be inserted between the motor (30) and the spindle (27).

15 The central clamping device (5) comprises two workpiece holders (6, 7), which are arranged at axially spaced locations from one another and hold and clamp the central workpiece (2) in the vicinity of the front ends with suitable clamping means. The workpiece holders (6, 7) are equipped with a travel carriage or holder carriage (8, 9) each and can move independently from one another along the carriage guide (12) and the upsetting axis (41). The workpiece holders (6, 7) or their holder carriages (8, 9) are connected to the respective associated adjusting unit (17, 18) via a rod-shaped carriage adjuster (31, 32) in a positive-locking manner. The carriage adjuster (31, 32) is

fixed rigidly, e.g., to the travel carriage (19, 20) of the adjusting unit (17, 18) and is moved along during the travel motions of the adjusting unit (17, 18). The carriage adjusters (31, 32) engage associated workpiece holders (6, 7) or holder carriages (8, 9) at the other end via one or more carriers (33) in a positive-locking manner. Carrying takes now place during the forward and 5 backward travel.

A spring (34) is inserted in the direction of the machine center between the carrier (33) and the workpiece holder (6, 7) and the holder carriages (8, 9). It brings about the absorption of the evading motions of the workpiece holders (6, 7) during upsetting. The central workpiece (2) undergoes deformation under pressure at the very strong upsetting forces occurring, which may reach up to 20 10 tons or more, and the workpiece holders (6, 7) move against the restoring force of the spring (34) and migrate to the axial center of the machine. After the upsetting pressure or the upsetting force is relieved, reverse motion into the starting position takes place while the spring (34) is released.

The welding heads (13, 14) are designed corresponding to the selected welding technique and are equipped with travel carriages (15, 16). They have chucks to receive and clamp the left and right 15 workpieces (3, 4). For friction welding, the welding heads (13, 14) may have a rotary drive for the chuck, as a result of which the corresponding workpiece (3, 4) is rotated in relation to the preferably stationary central workpiece (2) for friction. For welding with a magnetically moved arc, the arc unit needed for this is arranged at the welding heads (13, 14) and/or at the central clamping device (5) with a coil for deflecting the arc, etc. If other pressure welding techniques are used, which bring 20 about heating of the boundary surfaces of the workpieces (2, 3, 4) to be welded together in another manner, the welding heads (13, 14) have a correspondingly different design.

The feed drive (23) of the corresponding adjusting unit (17, 18) acts on the welding heads (13, 14) on the rear side. The feed drive (23) is preferably aligned with the workpieces (2, 3, 4) in the common feed axis (41) or is possibly arranged in parallel thereto at a closely spaced location. The feed drive (23) brings about the feeding of the corresponding welding head (13, 14) from the withdrawn inoperative position shown in Figure 1 into the working position shown in Figure 2. The boundary surfaces of the adjacent workpieces (2, 3, 4) come into contact depending on the welding process in the working position or are positioned at a certain distance from one another. Depending on the welding process, they are held in this position for some time or are moved on.

Friction feed directed toward the machine center takes place during friction welding. During welding with arc moved magnetically or according to another method, the welding heads (13, 14) at first remain stationary in the feed position. In addition, the necessary upsetting stroke directed against each other is applied with the needed upsetting forces or upsetting pressures at the end of the pressure welding process by means of the feed drives (23), which are preferably aligned axially. After the end of the pressure welding process, the feed drives (23) will again return the welding heads (13, 14) into the starting position according to Figure 1. Unloading and loading of the pressure welding machine 1 with the workpieces (2, 3, 4) is possible in this starting position.

The feed drives (23) are preferably of the same design. They may have any desired embodiment. In the exemplary embodiment being shown, they are hydraulic cylinders (24), which are arranged and supported in the structures of the adjusting units (17, 18). The piston rods of these cylinders are connected to the corresponding welding head (13, 14). As an alternative, they may be electric motor drives with extensible spindles or the like. Besides, any other desired types of drive

technique are possible.

The pressure welding machine (1) has a measuring means (35) for measuring the true feeds during the welding process and the pure workpiece shortenings occurring in the process without being affected by the above-mentioned elastic upsetting deformation of the central workpiece (2). The measuring means (35) is of independent significance and can also be used successfully in other types of pressure welding machines, especially those according to the state of the art. This applies, e.g., to pressure welding machines (1) with stationary adjusting units (17, 18) or stationarily arranged feed drives (23).

The measuring means (35) has at least one measuring unit (36, 37) arranged between a workpiece holder (6, 7) and the associated welding head (13, 14). In the exemplary embodiment being shown with two displaceable welding heads (13, 14), two such measuring units (36, 37) are present. The measuring units (36, 37) comprise each a rod- or bar-shaped scale (38) and a measuring head (39), which are arranged movably in relation to one another at the workpiece holder (6, 7) and at the respective associated welding head (13, 14). In the exemplary embodiment being shown, the scale (38) is arranged at the workpiece holder (6, 7) and is directed along the feed axis (41). It extends from the workpiece holder (6, 7) rearwardly to the associated welding head (13, 14). The scale (38) is designed, e.g., as a glass rod and carries a scale of path markings. The reading head (39) is arranged at the welding head (13, 14) in this embodiment and is directed toward the associated scale (38). The measuring head (39) may be, e.g., an optical path measuring unit, which reads the markings on the scale (38). As an alternative, any other suitable path-measuring technique may be used, the scale (38) and the measuring head (39) being of a corresponding design. The kinematic

association shown in the drawings may also be reversed, in which case the measuring head (39) is located at the workpiece holder (6, 7) and the scale (38) at the welding head (13, 14).

The relative axial motion between the workpiece holder (6, 7) and the welding head (13, 14) can be measured with high accuracy by means of the measuring units (36, 37). This relative motion

5 indicates the exact friction and upsetting path during friction welding. As a result, the component shortening of the entire welded part, brought about by the friction welding, is obtained from the sum of the left and right paths. During welding with magnetically moved arc, the workpieces are subsequently brought into spaced locations to ignite the arc after an initial contact, and the positioning necessary for the process and the distance of the workpieces (2, 3, 4) to be welded  
10 together are set by means of the measuring units (36, 37) and the motion is carried out to reach the given position. The resulting shortening of the workpiece can be determined after the subsequent upsetting stroke.

Furthermore, the measuring means (35) may have a central measuring unit (40), which is arranged, e.g., between the workpiece holders and/or optionally also between the welding heads (13, 14). The  
15 overall length of the workpieces (2, 3, 4) before the welding and also after the welding can thus be determined. The central measuring unit (40) is schematically indicated in Figure 1. It may have any desired and suitable design and likewise have one or more rod-shaped scales (38) and measuring heads (39).

The welding heads (13, 14), the adjusting drive (25), the adjusting units (17, 18) with the feed

20 drives (23) and the measuring means (35) are connected to the machine and process control and are

controlled and regulated by this with suitable programs.

Various modifications of the embodiment being shown are possible. This applies to the embodiment of the central clamping device (5), the welding heads (13, 14), the adjusting units (17, 18) and the adjusting element (26) along with the adjusting drive (25). The frame (11) may also have a different design. The type and the arrangement of the travel carriages (8, 9, 15, 16, 19, 20) are selectable as desired. This also applies to the type and the arrangement of the carriage guide (12).

## **LIST OF REFERENCE NUMBERS**

- 1 Pressure welding machine, double-head machine
- 2 Workpiece, central
- 3 Workpiece, outer, left
- 5 4 Workpiece, outer, right
- 5 Central clamping device
- 6 Workpiece holder
- 7 Workpiece holder
- 8 Travel carriage, holder carriage, left
- 10 9 Travel carriage, holder carriage, right
- 10 Frame
- 11 Machine bed
- 12 Carriage guide
- 13 Welding head, left
- 15 14 Welding head, right
- 15 Travel carriage, upsetting carriage, left
- 16 Travel carriage, upsetting carriage, right
- 17 Adjusting unit, left
- 18 Adjusting unit, right
- 20 19 Travel carriage, adjusting carriage
- 20 Travel carriage, adjusting carriage

- 21 Nut, left
- 22 Nut, right
- 23 Feed drive, upsetting drive
- 24 Cylinder, hydraulic cylinder
- 5 25 Adjusting drive
- 26 Adjusting element
- 27 Spindle
- 28 Thread, left
- 29 Thread, right
- 10 30 Motor, spindle motor
- 31 Carriage adjuster, left
- 32 Carriage adjuster, right
- 33 Carrier
- 34 Spring
- 15 35 Measuring means
- 36 Measuring unit, left
- 37 Measuring unit, right
- 38 Scale
- 39 Reading head
- 20 40 Measuring unit, central
- 41 Feed axis, upsetting axis